

ORGANIC CHEMISTRY

A. FROM ORGANIC CHEMISTRY TO BIOCHEMISTRY _____

1

Read Carbon chemistry and find words matching the following definitions.

- smallest substance into which a substance can be divided without changing its chemical nature - O _____
- body-building substance made up of amino acids - E _____
- scientific study of life - Y _____
- scientific study of the chemistry of living organisms - O _____
- substance that makes a person unable to feel pain - A _____
- compound made up of large molecules which are in turn made up from combinations of smaller molecules - Y _____
- compound of hydrogen and carbon - C _____
- structural fragment found in all members of a class of compounds - U _____ G _____

CARBON CHEMISTRY

The diversity of carbon chemistry is responsible for the diversity of life itself. The ability to form a virtually unlimited range of compounds has led to an almost unlimited range of living organisms constructed out of molecules containing carbon. You yourself are a unique individual because you contain unique proteins: only carbon could form the basis of a range of compounds diverse enough to provide a different one for every individual.

Because the major source of compounds containing carbon and hydrogen is living or once-living material (animals, plants, coal, oil), it was originally thought that only living organisms could produce these compounds. This has since been shown to be untrue, but the name 'organic' has continued to be applied to that branch of chemistry concerned with the study of compounds containing C-H bonds. This includes the vast majority of carbon compounds, but traditionally compounds such as CO, CO₂ and carbonates have been considered to belong to the field of inorganic chemistry.

The position of carbon as the basis of the molecules of life means that the study of organic chemistry is of central importance in understanding the chemistry, and therefore the biology, of living systems (the chemical study of living systems is called biochemistry). The knowledge of organic chemistry enables chemists to develop and manufacture drugs, agricultural chemicals, anaesthetics and other chemicals whose interactions with life processes are important to man. Many other organic chemicals, less directly related to biological compounds, are of prime importance to modern society, for example the many polymers (polythene, nylon) whose properties of flexibility and elasticity are a direct consequence of carbon's unique ability to form chains.

The ability of carbon to form strong bonds to itself and to hydrogen leads to the formation of stable compounds, called hydrocarbons, containing only carbon and hydrogen. All molecules ►

containing the same functional group can be considered as members of a family, with similar properties. Of course, as the hydrocarbon chain gets bigger it increasingly dominates the properties of the compound, so that members of the family show a steady gradation of physical and chemical properties as the size of the hydrocarbon portion increases.

A family of compounds containing the same functional group is called a homologous series.

(From: Hill-Holman, *Chemistry in Context*, Nelson)

- 2** Use these words to complete the summary of Carbon chemistry: carbon, carbonates, covalent, electrons, four, homologous, inorganic, organic, oxides.

Over two million compounds are known which contain the element (1) and about eighty thousand new compounds are made each year. It is therefore convenient to study such compounds separately, and this branch of chemistry is known as (2) chemistry. Today the distinction between organic and (3) chemistry is an arbitrary one. Organic chemistry is regarded as the chemistry of the compounds of carbon other than its (4), the metallic (5) and related compounds. The bonds which carbon forms are (6): that is, each bond is formed by the sharing of two (7), one of which is provided by the carbon atom and one by the other atom. The large number of organic compounds fall into a comparatively small number of series, known as (8) series.

- 3** Match nouns a-f, as they are used in the passage Carbon chemistry, with their synonyms 1-6. Tip: copy the pairs in your indexed book.

- | | | |
|----------------|--------------------------|----------------|
| a. diversity | ☐ | 1. amount |
| b. field | ☐ | 2. discipline |
| c. drug | ☐ | 3. medicine |
| d. interaction | ☐ | 4. progression |
| e. gradation | ☐ | 5. relation |
| f. size | ☐ | 6. variety |

- 4** Match adjectives a-f, as they are used in the passage Carbon chemistry, with their synonyms 1-6. Tip: copy the pairs in your indexed book.

- | | | |
|--------------|--------------------------|----------------|
| a. unlimited | ☐ | 1. exceptional |
| b. major | ☐ | 2. fundamental |
| c. untrue | ☐ | 3. incorrect |
| d. central | ☐ | 4. infinite |
| e. unique | ☐ | 5. prime |
| f. steady | ☐ | 6. stable |

- 5** Match verbs or adverbs a-f, as they are used in the passage Carbon chemistry, with their synonyms 1-6. Tip: copy the pairs in your indexed book.

- | | | |
|-----------------|--------------------------|-------------------|
| a. provide | ☐ | 1. allow |
| b. belong | ☐ | 2. be appropriate |
| c. enable | ☐ | 3. more and more |
| d. manufacture | ☐ | 4. practically |
| e. increasingly | ☐ | 5. produce |
| f. virtually | ☐ | 6. supply |

B. ORGANIC COMPOUNDS: ALIPHATIC COMPOUNDS vs. AROMATIC COMPOUNDS

B.1 ALKANES, ALKENES, AND AROMATIC HYDROCARBONS

The principal sources of alkanes are *natural gas and petroleum*. Natural gas contains mainly methane, with smaller amounts of the other gaseous alkanes such as ethane, propane and butane. Petroleum contains a wide range of alkanes.

The uses of petroleum, both *as a fuel and as a source of chemicals*, are of outstanding importance. *Natural gas* is by far the most important source of methane.

Alkanes were once known as the ‘paraffins’, *from the Latin words ‘parum’ (little) and ‘affinitas’ (affinity)*. Hence there are only a few reactions of alkanes, but these are of great importance. The combustion products of alkanes are *carbon dioxide and water*, if the oxygen supply is plentiful. If the oxygen supply is limited, *the products may include carbon monoxide and carbon*.

The combustion of hydrocarbons in general and alkanes in particular is of immense importance, *for it occurs in power stations, furnaces, domestic heaters, candles, gas heaters, internal combustion engines and many other devices essential to a technological society*.

When alkanes are heated to high temperatures their molecules vibrate strongly enough to break bonds and form smaller molecules, one of which is an alkene. Such reactions are known as ‘cracking’. By using a catalyst, cracking can be made to occur at fairly low temperatures. This is known as ‘catalytic cracking’. Cracking is very important in the petroleum industry. It is used to provide extra gasoline and as a source of alkenes.

Ethene and propene are the first two members of the homologous series of alkenes. All members of this series contain a double carbon-carbon bond. They therefore have two atoms of hydrogen less than the corresponding alkane. *Because they contain less than the maximum amount of hydrogen*, they are said to be unsaturated. The melting points and boiling points of the alkenes are very close to those of the alkanes. Ethene, propene and the butanes are gases at room temperature, and the higher members are liquids.

What do PVC raincoats and antifreeze have in common? Or polythene bottles and adhesives? Like many other things in everyday use, they are made from ethene, the simplest alkene and the most versatile organic compound in use today. *Ethene can be used as building block to prepare complex organic molecules*. Propene is used in a similar way. The necessary large quantities of these alkenes are manufactured *by cracking processes*.

The simplest and most important member of the aromatic hydrocarbons is *benzene*. The name ‘aromatic’ was originally used *because some derivatives of these hydrocarbons have pleasant smells*. It is now known that just as many of them smell unpleasant, and in any case many of the aromatic vapours are toxic, so it is unwise to smell them. The name aromatic has been retained to indicate certain chemical characteristics rather than odorous properties.

Benzene is a colourless liquid with a characteristic odour. It is insoluble in water but soluble in all organic solvents, and it is itself a very good solvent for organic compounds. It freezes at 5°C and boils at 80°C. *Both the liquid and the vapour are highly poisonous*, so that benzene must be used with care. Detergents, polystyrene, nylon and insecticides can all be made from benzene. In the past, *benzene was produced as a by-product of the destructive distillation of coal*.

6 Ask questions about the phrases in *italics* in the passage Alkanes, alkenes and aromatic hydrocarbons.

7 Use these words to complete the review of hydrocarbons below: ability, air, bonds, chains, covalent, electrons, ethene, families, fuels, homologous, hydrogen, important, isomers, saturated, unsaturated.

Hydrocarbons are compounds that are made from the elements (1) and carbon. They are all (2) compounds. Carbon has four (3) in its outer shell. A carbon atom always has four covalent (4) linking it with other atoms.

There is a very large number of organic compounds because of the (5) of carbon atoms to form covalent bonds with other carbon atoms and so form (6) Within the hydrocarbon group, compounds are divided into even smaller groups called (7) series. The simplest of these is called the alkanes, often called (8) compounds. The names of the alkanes are very (9) because the names of all other organic compounds are based on them. Alkanes are useful (10) They burn easily in (11) to form carbon dioxide and water.

There are several other (12) of hydrocarbons, the alkenes being the most important. The simplest member of the alkene family is (13) All the alkenes contain a double bond between two carbon atoms. A hydrocarbon that contains a multiple bond between two carbon atoms is said to be (14) When the length of the carbon chain in the hydrocarbons is greater than three, it is possible to have compounds with the same formula but different structures called (15)

8 Read Crude oil and answer the questions below.

B.2 CRUDE OIL

Crude oil was formed from the remains of small marine animals and plants that were buried in the beds of the seas millions of years ago. The decay of these remains under the layers of overlaying rock formed the liquid known as crude oil or petroleum (from Greek + Latin words meaning 'rock oil'). Similar conditions led to the formation of the natural gas that is often found associated with crude oil as well as in deposits on its own.

Crude oil is a complex mixture of hydrocarbons. It has no uses in its raw form. To provide useful products, its components must be partly separated and, if necessary, modified. Once crude oil has been located and extracted, it must therefore be transported to a refinery where it is processed.

The different fractions are used as follows.

The main use of refinery gas is as a gaseous fuel, but, like natural gas, it can be used as a starting point for making petrochemicals.

Gasoline is a complex liquid mixture of hydrocarbons. The major use of gasoline is of course as a fuel in internal combustion engines. The part of the gasoline fraction used to produce chemicals is called naphtha.

Kerosene is used as a fuel in jet engines and for domestic heating purposes. It can also be cracked to produce extra gasoline.

Diesel oil or gas oil is used in diesel engines.

The residual oil from the primary distillation is a highly complex mixture of involatile hydrocarbons. Most of it is used as fuel oil in large furnaces such as those in power stations or big ships. A proportion of it, however, is used to make lubricating oils and waxes.

To obtain lubricating oil and paraffin wax from the residue, the appropriate hydrocarbons must be distilled off. Paraffin wax is separated from lubricating oil by solvent extraction. The solid left after vacuum distillation is an involatile tarry material called bitumen or asphalt and is used to surface roads and to water-proof materials.

Hydrocarbons, which make up the more volatile fractions of crude oil, are the main and the most important components. Three different homologous series of hydrocarbons are present: alkanes, cycloalkanes and aromatics.

(from: Hill-Holman, *Chemistry in Context*, Nelson)

- a. What was crude oil formed from?
- b. Where does the word 'petroleum' derive from?
- c. How are lubricating oil and paraffin wax obtained from the residue?
- d. What are the main components of crude oil?

9

What are these substances mentioned in Crude oil used for: refinery gas, gasoline, kerosene, diesel oil, residual crude?

10

Find out to which of these words the couples of words and phrases listed below refer to: bed, decay, located, remains, tarry, wax. Then choose the correct meaning of each word, as used in Crude oil.

- a. dead bodies / ruins
- b. bottom of a water body / piece of furniture
- c. decomposition / loss of vigour
- d. discovered / situated
- e. substance produced by bees / substance obtained from oil
- f. delaying / tarlike

C. POLYMERS

D. THE EXCITING WORLD OF SYNTHETIC POLYMERS

POLYMER-BASED PRODUCTS COUNTDOWN

10. What do pantyhose and parachutes have in common? They both contain polyamide as a base material. Polyamide is better known under its trade name: nylon. This polymer is also used to make ropes, swimwear and boat sails. Polyamide is not only strong and durable, but also moisture-resistant and has an ample temperature resistance. Nylon is a component of bottles, solvents and food packaging, as well.
9. Non-stick cookware and cooking utensils are made using polytetrafluoroethylene, or PTFE for short. PTFE is a waxy, thermally stable material that's tough, corrosion resistant and non-flammable. It can resist temperatures of up to 260°C, which makes it ideal not only in the production of cooking products, but also as a cable insulator and sealant. A porous form of PTFE is the base material of a highly breathable waterproof fabric used to make sports uniforms and exercise gear.
8. Liquid-absorbing crystals are polymers that can absorb several times their weight in water. Their most popular application is as filler for disposable diapers, but they're also used in humidors and first-aid packs, and as fire retardants and drink chillers. Liquid-absorbing crystals are particularly useful in gardening and landscaping. Because they retain water, they can reduce the need for watering by up to 80 percent.
7. Despite their different looks and feels, containers like foam cups, grocery store meat trays and disposable cutlery are all basically the same product. These items are all made from polystyrene, a plastic with limited flexibility that's also used to make DVD cases, disposable razors and refrigerator insulation. Polystyrene is one of the polymers that can be recycled in most of its forms.
6. Polyethylene terephthalate, or PET, is probably the best-known and most widely used polymer in existence. From soft drink bottles to milk containers, PET can be found in pretty much any container in your refrigerator. This material is the most recyclable of all plastics.
5. Spandex clothing fibre is made of polyurethane, a quick-drying, highly elastic polymer which is used in a number of clothing items, including sports uniforms, bathing suits, exercise clothing, leggings, skinny jeans, socks and wetsuits. Even bra straps and disposable diapers are made using spandex polymers.
4. Polyolefin is widely used in the construction industry. It is also used in the production of textiles, because it has a unique feature: it can be melted and turned into a fine fibre. Common items that contain polyolefin include mattress covers, lining fabrics and upholstery, insulated socks, disposable hospital garments, rope and nets, woven sacks and bags, and disposable diapers.
3. Polycarbonate is one of the most versatile polymers. It is used to make computer cases, CDs, automotive and aircraft components, toys and riot shields. Polycarbonate has been used to make high-quality eyeglass lenses which are lighter and thinner than glass, offer UV protection and are impact resistant. Polycarbonate is also used to make sports goggles, car headlights, projection screens, helmets and visors. Diffuser sheets for LCD flat screens are also made from polycarbonate.
2. Basically all hairdressing products contain polymers. For example, polymers are used in conditioners and they're also added to shampoos as a thickener. 

1. Polyvinyl chloride, or PVC, is the material used to make plumbing fittings and pipes, but PVC is also used to make credit cards. The same PVC material is used to make leather-like materials for clothing and shoes, vinyl records, synthetic floor tiles and electric wire insulation and commercial signs and banners.

11

'Tidy up' these items mentioned in Polymer-based products countdown and put them into the right place(s) in the table below. Tip: copy the table in your exercise book.

automotive and aircraft components	bathing suits	boat sails
bras	cable insulators	car headlights
computer cases	cookware	disposable cutlery
disposable razors	DVD cases	electric wire insulation
exercise gear and clothing	fire retardants	first-aid packs
foam cups	food packaging	hairdressing products
leggings	mattress covers	meat trays
panty hose	parachutes	sealants
socks	solvents	sports goggles
swimwear	synthetic floor tiles	wetsuits

KITCHEN	LIVING-ROOM STUDY	BEDROOM WARDROBE	BATHROOM	SPORT CENTRE / SPORT RESORT	CONSTRUCTION INDUSTRY

12

Choosing from phrases 1-10 below, find the 'happy ending' for phrases a-j to make a short summary of Polymer-based products countdown.

- a. Polyamide (nylon) is especially useful because
 - b. Nonstick cookware is made using PTFE because
 - c. Liquid-absorbing crystals are used in disposable diapers because
 - d. Most takeout containers are made from polystyrene because
 - e. PET is possibly the best-known polymer because
 - f. Polyurethane is used in many of clothing items because
 - g. Polyolefin is extensively used in the textile industry because
 - h. Many eyeglass lenses are made from polycarbonate because
 - i. Hairsprays contain polymers because
 - j. Among its many applications, PVC is used to make clothing and shoes because
-
- 1. it can be liquefied and turned into a fine fiber.
 - 2. it can resist very high temperatures.
 - 3. it is a type of plastic with limited flexibility.
 - 4. it is quick-drying and highly elastic.
 - 5. it is the most widely used.
 - 6. it looks like real leather.
 - 7. it's light, thin and impact resistant.
 - 8. it's strong, durable, and resistant to moisture and temperature.
 - 9. they are what helps hold hair in place.
 - 10. they can absorb several times their weight in water.